Influence of Different Types of Mulching on Corn Growth and Soil Temperature as

Abd Alrahman P. Haydar [1]

[1] University of Salahaddin - College of Agriculture

Abstract

Soil temperature and water limitations are the most important factors that affect on corn growth during different stages of its development. Mulching is an effective strategy to moderate soil temperature and conserve soil moisture through reducing evaporation. A study was made during July through Sept. 2016 at the experimental field of the Agriculture College, Salahaddin University at Girdarasha site/Erbil. The main objective was to study the effectiveness of different colors of the plastic films and two organic mulches on the growth of two hybrids of corn grown in a silty clay loam soil. The results indicate that irrespective of mulch type, mulching resulted in a higher soil temperature compared with the unmulched soil. All of the applied mulches exhibited similar trends during different stages of corn growth. It was also observed that mulching resulted in an increase in the aboveground biomass yield by 16.38% to 31.1%. Among different plastic mulches, the white plastic mulch gave the highest biomass production. Conversely, the plant height and the biomass production were the lowest under the blue mulch treatment.

Key words: Soil temperature, Mulch, Colored plastic mulch, Biomass, Growth, Corn hybrids.

الخلاصة

يعتبر تحديد حرارة و رطوبة التربة من العوامل الاكثر اهمية التى تؤثر في نمو الذرة في المراحل المختلفة من النمو. ان عملية التغطية هي من الاستراتيجيات الفعالة لتعديل حرارة التربة والحفاظ على رطوبة التربة من خلال تقليل التبخر.اجريت الدراسة خلال شهر تموز ولغاية ايلول 2016 في حقول كرده ره شه التجريبية التابعة لكلية الزراعة- جامعة صلاح الدين/ اربيل.كان الهدف الرئيسى للبحث دراسة فعالية الالوان المختلفة من الغطاء البلاستيكى ونوعين من الغطاء العضوي في نمو هجينين من نباتات الذرة الصفراء المزروعة في تربة غرينية طينية طمية. تشير النتائج وبغض النظر عن نوعية التغطية ، ان معاملات التغطية اعطت درجات حرارة اعلى من ما مقارنة بمعاملة المقارنة ، والمعاملات التي استخدمت فيها الكساء كانت نتائجها باتجاهات مشابهة خلال المراحل المختلفة من نمو النبات ، وكما لوحظ بان التغطية ادت الى زيادة في انتاج الكتلة الحيوية على سطح التربة ، والزيادة كانت بمقدار اقصاها 31،1% وادناها 16،38% مقارنة بمعاملة المقارنة .

Introduction

During the last decade, many industries have developed a variety of colored plastic films for mulching, which have additional benefits related to altered quantity of reflected light into plant canopy (Andino and Motsenbocker, 2004). Kasirajan and Mathieu, 2012 reported that the use of plastic mulch in agriculture has increased dramatically due to their benefits such as increase in soil temperature, control weeds, moisture conservation through limiting soil water evaporation, higher crop yields, reduction of certain insect pests, and more efficient use of soil nutrients. Plastic film mulching has been a common agricultural practice since it was introduced to china in 1978 (Dong et al. 2009), and it has the effect of regulating the environment, suppressing weeds, controlling crop growth and pests and diseases (Mahajan et al. 2007). Mulching is an important agricultural practice, the use of plastic mulch in field crops such as corn, cotton, sugar cane, and rice is successfully used in many countries (Kasirajan and Ngouajio 2012). Soil mulching with plastic film leading to reduced water loss and more even regulation of soil temperature (Zhang et al. 2005). Higher germination ratio obtained in the plastic mulch compared to straw mulch and bare soil, this was due to an increase in soil temperature under the plastic mulch (Burhan and Bekir 2013), thereby promoting faster crop development (Guo and Gu 2000). The plastic film is a barrier preventing soil water evaporation thus keeping the moisture regime in the root zone at more stable levels. This can reduce irrigation demands (McCraw and

Motes 1991), different types of colors of plastic mulch have characteristic optical properties that change the levels of light radiation reaching the soil, causing increases or decreases in soil temperature (Ham et al. 1993). Removal and disposal of plastic mulches from the field after cropping is one of the major problems, withal the greater initial costs of plastic mulch due to investment in some specialized equipment, including a bed press, mulch layer, and mulch transplanter or plug-mix seeder will increase the cost of production for a given crop (Lament, 1993)

Materials and Methods

Description of the study area

The experiment was conducted in summer 2016 (17thJuly to September) at the experimental field of the Agriculture College, Salahaddin University at Girdarasha site located at about 4.0km south of Erbil city(44˚ 1′ E, 36˚6′ N) and at an altitude of 420m above mean sea level. The soil of the experimental site is a silty clay loam texture with a 38.90 % Clay, 47.66% Silt, and13.44 % Sand. The climate of the site is Mediterranean, based on 35 years of record; the mean annual rainfall is 445mm distributed unequally through the months of November to April. The average monthly maximum and minimum temperatures are 35.6˚C at July and 5˚C at January respectively.

Experimental Design and Treatments

A factorial CRD with two factors was designed. The first factor was colored plastic mulches (PM) encompassing black, blue, and white films, in addition to these films, wheat straw and saw dust were used as organic mulches. The second factor was two hybrids of the corns named Cades and Draghma. The experiment was performed in three replicates for each treatment.

Field preparation and ameliorating the plants

Before initiating the experiment, thirty six (36) pits were excavated on three rows, the excavated soil was air dried, gently crushed and thoroughly mixed and passed through a 4-mm sieve. Thereafter the sieved soil was moistened to close soil moisture to optimum water content for compaction. Plastic containers with 18.5liters capacity were filled with prepared soil up to 2cm from the upper rim of the container which left empty for irrigation. The soil was compacted by a manual compacter to its bulk density of 1.37Mg m^{-3}. Following the filling the containers, they buried into the pits such that the upper rim of the container were at the same level of the land surface. Laying the mulches was after thinning the plants and leaving one plant for each container.

Mulching materials

The mulching materials encompassed six treatments, three of them were plastic mulches which included, black, white, and blue PM with an average thickness of 0.22 mm in thicknesses were measured by an electronic digital caliper, the transmitted light through the polyethylene films was measured by light meter model 401025(EXTECH INSTRUMENS), and obtained values were 0.25, 71, and 54% respectively for the mentioned plastic mulches. The other treatments included two types of organic mulches: wheat straw (2.65t/ha) and sawdust (4.07t/ha), and the un-mulched containers were treated as control.

Irrigation

At 10 cm height the plants thinned to only one plant remained per each container Plant density was 15plants/m^2. The predetermined amounts of irrigation water according to the consumptive use -ET_c- for the plant growth stages were used.

Data collection

a- Leaf area and height of the plant

The leaf area for the corn plants was determined by measuring the leaf length and the maximum width of the leaf, and the area was calculated using the following equation:

Area= length* width * 0.75 (McKee, 1964)

Measuring tapes used for measuring the height of the plants from the soil surface up to the base of the male spike.

b- Biomass and root mass

At a maturity crop stage the total biomass over the soil surface and the washed root for each plant was collected and heated at 105˚C for 30 minutes, then dried at 75˚C to a constant mass before weighing, all mass values are expressed in relation to the dry mass**.** The determined biomass and the root mass were based on the average of the three treatment replicates. (Ling, et al., 2013)

c- Soil Temperature

From the 10cm depth the daily soil temperature was recorded at two different times at 8:30 Am and 2:30 Pm using the installed soil thermometers were used for measuring, and the average soil temperature was calculated for each stage of the plant growth, and the stages were determined according to (Allen et al. 1990)

d- Chlorophyll content

Chlorophyll content in leaves was measured by Chlorophyll meter SPAD-502.

Tastical analysis

The Analysis of Variance (ANOVA) and Duncan's Multiple Range Tests of the Statistical Analysis System (SAS 9.1) Software was used for performing the Data analysis.

Results and discussion

Soil temperature

Generally soil temperature from mulched treatments were having higher values than those treatments without mulching, soil temperature was dependent upon the type of plastic films and the other two organic mulches, the effects were more obvious during the early stage of the corn growth **.** Fig. (1a) and (1b) shows that at the 1st period- 8:30 Am- the average of the highest soil temperatures by blue PM -25.7˚C from Draghma hybrid, and 25.6˚C from Cades hybrid- and the lowest soil temperatures by un-mulched treatments-21.2˚Cfrom Draghma hybrid, and 21.4˚C from Cades hybrid-were recorded. These results which match with an expected fact: the greatest net radiation which transmitted was through blue plastic mulch and can be determined as a highest amount of energy that reaches to the soil, thereby rises the soil temperature. These results is in agreement with the findings of Ham et al., (1993), and Tesfaye et al., (2016) who reported that optical properties as characteristics of different plastic mulch change the level of solar energy reaching the soil, causing increases in soil temperature. During the different stages of the corn growth the maximum temperatures were at development stage for all treatments, while the minimum temperature was at harvesting stage (Fig. 2a and 2b).This may because of the full establishment of the plant canopy in the middle and harvesting stages which leads to little increase in the soil temperature especially with plastic mulching comparing with un-mulched

treatments, and this is in consistent with those reported by researchers [Zhou et al. (2009), and Lalitha et al., (2010) who observed that soil temperature is usually higher affected by plastic mulching during the early stages of growth because of sparse crop cover, and this effect decreased with canopy

growth with advancing the time.

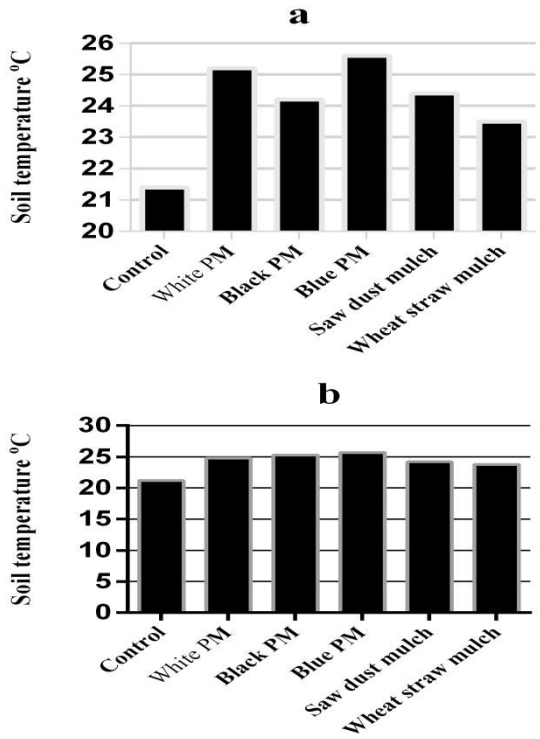

Fig (1) Effect of different types of mulches on the average soil temperature (^{o}C)

a. Cades Hybrid
b. Draghma Hybrid

Table 2: Effect of different types of mulching on soil temperatures (˚C) at10cm depth.

Treatments	Duncan's grouping		
	Development stage	Mid stage	Harvesting stage
Unmulched	25.6 c	21.6 c	16.7 b
Black PM	30.04 a	24.8 a b	20.1 a
White PM	29.8 a b	24.9 a b	20.3 a
Blue PM	29.4 a b	26.4 a	20.6 a
Wheat straw mulch	28.2 b	23.2 b	19.4 a
Sawdust mulch	28.8 a	24.6 b	19.7 a

In a column, all numbers that bear same letter (s) are not significantly different at 5% of probability.

It has been noticed that the extreme rising values (> 34˚C) of soil temperature under transparent PM caused dying plants at the early time of the development stage, Similarly Maged, (2006) who observed that the value of soil temperature under transparent mulch is higher than those under other mulches.

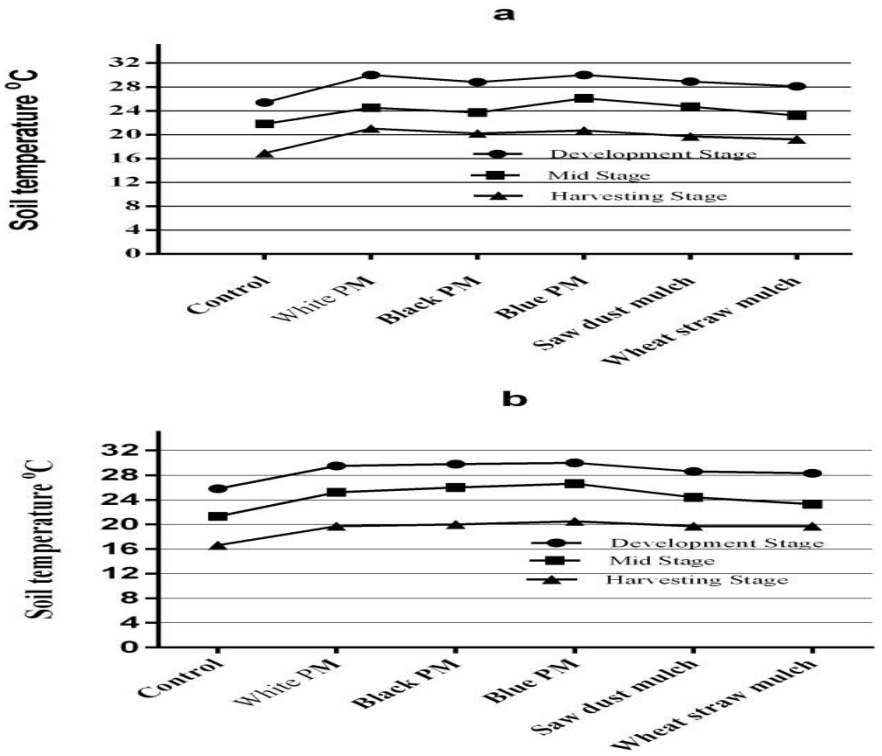

Fig (2) Effect of different types of mulches on soil temperature (^{o}C) through growth stages a. Cades Hybrid
b. Draghma Hybrid

Statistical analysis of the obtained soil temperatures at the second period (2:30 Pm) of the experiment revealed that the mulching significantly increased soil temperature at ($P \leq 0.05$) comparing to unmulched treatments for both hybrids throughout the different growth stages of the corn plant. Table(2) shows that the only blue PM was significantly different with organic mulches at the mid stage.(Table3),represents the effect of the interaction between treatments under different types of mulches for both hybrids upon soil temperature and it can be noticed that soil temperature was significantly increased by mulching in both corn hybrids compared to unmulched treatment at the three studied stages of the plant growth, except the treatment which was under wheat straw mulch at the mid stage, while the wheat straw was significantly different from the blue PM at the mentioned stage, this may owing to the moderating effectiveness of organic mulches on soil temperature besides the conserved soil moisture along this stage.

Table3: Effect of different types of mulching and corn hybrids on soil temperatures (˚C) at 10cm depth.

Interactions	Mean soil temperature (˚C) and Duncan's grouping		
	Development stage	Mid stage	Harvesting stage
Control- Draghma	25.4 b	21.8 d e	16.9 b c
Control- Cades	25.8 b	21.3 e	16.55 c
Black PM-Draghma	30.3 a	23.7 b – c	20.2 a
Black PM- Cades	29.8 a	26 b a	20 a
White PM- Draghma	30.02 a	24.6 a-c	21 a
White PM- Cades	29.5 a	25.2 a-c	19.65 a
Blue PM- Draghma	28.8 a	26.1 a	20.65 a
Blue PM- Cades	30.02 a	26.6 a	20.5 a
Wheat straw mulch- Draghma	28.1 a	23.2 c-e	19.17 a
Wheat straw mulch- Cades	28.2 a	23.3 c-e	19 67 a
Sawdust mulch- Draghma	29 a	24.7 a-c	19 66 a
Sawdust mulch- Cades	28.6 a	24.4 a-c	19.67 a

In a column, all numbers that bear same letter(s) are not significantly different at 5% of probability.

Biomass

It is palpable from Table (6), that mulching had different effects on the total biomass of corn plants. The maximum value of plant dry matter was recorded by black plastic mulch (24.6 t ha^{-1}) and the minimum value was (17.63 t ha^{-1}) obtained by blue plastic mulch. The differences between black PM, white PM and wheat straw mulch treatments and unmulched treatment were 29.24, 48.59, and 49.68% respectively at Draghma hybrid, while the differences were 23, 15.3, and16.6% at Cades hybrid. The only two treatments white PM and wheat straw mulch significantly affected on the biomass yield at Draghma hybrid, these results reveal that Draghma hybrid response to the applied mulches were higher than Cades hybrid. An opaque blackbody absorber of black PM, high radiator of sun lights of white PM, and good moderating soil temperature character of wheat straw mulch may be the reasons of these results.

Table4: Biomass yield of treatments under different types of mulching and control

Treatments	LS mean and Duncan's grouping
Control	17.8 b
Black PM	22.4 a
White PM	23.1 a
Blue PM	20.2 a-b
Wheat straw Mulch	23.3 a
Sawdust Mulch	20.7 a-b

In a column, all numbers that bear same letter(s) are not significantly different at 5% of probability.

Table (4) represents the biomass yield under different types of mulch and it can be noticed that black PM, white PM and wheat straw mulches were significantly higher compared to unmulched treatment, while both of sawdust mulch and blue PM are not significantly different. There was also a significant difference with 32.44% between the produced biomass yield under blue PM

and the obtained value under wheat straw mulch treatment at Draghma hybrid, while the differences under different types of applied mulches were nonsignificantly affected on the biomass yield at Cades hybrid and the difference was only 2.19%, these may due to the differences that belong to the hybrids themselves.

Table5: Effect of different types of mulching and Corn hybrids on biomass yield of the corn.

Treatment-hybrid Interactions	LS mean and Duncan's grouping
Control- Draghma	15.6 c
Control- Cades	20 a-c
Black PM-Draghma	20.2 a-c
Black PM- Cades	24.6 a
White PM- Draghma	23.2 a
White PM- Cades	23.1 a
Blue PM- Draghma	17.6 b- c
Blue PM- Cades	22.8 a
Wheat straw mulch- Draghma	23.4 a
Wheat straw mulch- Cades	23.4 a
Sawdust mulch- Draghma	20.1 a-c
Sawdust mulch- Cades	21.3 ab

In a column, all numbers that bear same letter(s) are not significantly different at 5% of probability

Chlorophyll, plant height, and root mass

Blue PM exhibits differently comparing with other plastic mulches, from Table (6), it can be noticed that the maximum produced chlorophyll in both hybrids and minimum plant height were under blue PM, these results are in agreement with the findings of (Erick, 2015) who reported that blue light which is used for photosynthesis is highly absorbed by chlorophyll in plants, and plants grown under blue PM typically have shorter stems, because blue light usually acts to slow down expansion growth (Erick, 2015). The unexpected result was obtaining the maximum root mass from the treatment under blue PM which may conversely acts with principle facts of relation between biomass and root activities. The maximum values of plant heights were recorded by wheat straw mulch and white PM for both Cades and Draghma hybrids respectively.

Leaf area

Table (6) shows that the treatments under organic mulches acquired the primacy of the maximum values of leaf areas 456.7 and 432.7cm^2 under wheat straw and sawdust mulches respectively, and generally the effect of mulches upon leaf areas can be ranked as follow: Wheat straw mulch> Sawdust mulch> White PM> Black PM > Blue PM> control. The somewhat moderated soil temperature and the conserved soil moisture of the treatments under organic mulch is one the reasons of the obtained results.

Table 6: Some studied properties of the two hybrids of the corn plant

Treatments	Chlorophyll in the plant leaves (µmol m^{-2})		Average height of the crops (cm)		Average root mass (t ha^{-1})		Average bio mass (t ha^{-1})		Average leaf area (cm^2)	
	Cades hybrid	Draghma Hybrid	Cades hybrid	Draghma Hybrid	Cades hybrid	Draghma hybrid	Cades hybrid	Draghma hybrid	Cades hybrid	Draghma hybrid
Control	39.97	36.2	131.3	130.33	4.39	5.42	20	15.6	358.3	306.3
Black PM	42.37	42.87	149	135.33	8.27	7.41	24.6	20.2	379.3	366.3
White PM	43.53	40.8	140.67	140	14.09	5.59	23.06	23.18	379.3	398.6
Blue PM	46.27	44.43	134.33	137.67	14.88	12.14	22.82	17.63	355.3	330.3
Wheatstraw Mulch	44.43	41.33	151.33	131.33	14.18	8.46	23.32	23.35	445	468.3
Sawdust Mulch	42.13	38.77	142.33	137	6.48	7.27	21.3	20.13	417	448.3
Treatments	Chlorophyll in the plant leaves (µmol m^{-2})		Average height of the crops (cm)		Average root mass (t ha^{-1})		Average bio mass (t ha^{-1})		Average leaf area (cm^2)	
	Cades hybrid	Draghma Hybrid	Cades hybrid	Draghma Hybrid	Cades hybrid	Draghma hybrid	Cades hybrid	Draghma hybrid	Cades hybrid	Draghma hybrid
Control	39.97	36.2	131.3	130.33	4.39	5.42	20	15.6	358.3	306.3
Black PM	42.37	42.87	149	135.33	8.27	7.41	24.6	20.2	379.3	366.3
White PM	43.53	40.8	140.67	140	14.09	5.59	23.06	23.18	379.3	398.6
Blue PM	46.27	44.43	134.33	137.67	14.88	12.14	22.82	17.63	355.3	330.3
Wheatstraw Mulch	44.43	41.33	151.33	131.33	14.18	8.46	23.32	23.35	445	468.3
Sawdust Mulch	42.13	38.77	142.33	137	6.48	7.27	21.3	20.13	417	448.3

Conclusions and recommendations

These results have demonstrated that corn development and growth are affected by mulching**,** plastic mulches were more effective in increasing soil temperature than organic ones and all of them behaved similarly at different stages of the plant growth. Most of the applied mulches affected positively upon the produced dry matter, while blue PM solitude in its character and recorded the minimum dry matter product with the maximum value of root mass. On the bases of the obtained results it can be recommended that: 1**)** Using only one hybrid or species of a plant in such an experiment is better to avoid the expected interaction between them thereby the yield will be pure, 2**)** For increasing the yield via maximizing the fertility, this can be achieved by planting at minimum two rows of the same plants as a barrier at a 2-3m distance from the treatments, and 3**)**using transparent and light mulches under low external evaporativity may be more suitable for development and growth of the plants and give better results.

References

1. Allen,R. G., Pereira, L. S., Raes, D., & Smith, M. (1990). FAO irrigation and drainage paper No. 56. Guidelines for computing crop water requirements.
2. Andino, J. R., & Motsenbocker, C. E. (2004). Colored plastic mulches influence cucumber beetle populations, vine growth, and yield of watermelon. *HortScience*, *39*(6), 1246-1249.
3. Burhan K., & Beker A (2013). Effect of mulch practices on fresh ear yield and yield components of sweet corn. Turk J Agric. For. 37: 281-287.
4. Dong, H., Li, W., Tang, W., & Zhang, D. (2009). Early plastic mulching increases stand establishment and lint yield of cotton in saline fields. *Field Crops Research*, *111*(3), 269-275.
5. Erick, R. (2015). Light wave bands and their effects on plants. gpn. March 2015.www. GPNMAG.Com.
6. Guo, Z. L., & Gu, S. L. (2000). Effect of film mulching methods on yield and economic efficiency of millet. *Agric. Res. Arid Areas*, *18*(2), 33-39
7. Ham, J. M., Kluitenberg, G. J., & Lamont, W. J. (1993). Optical properties of plastic mulches affect the field temperature regime. *Journal of the American Society for Horticultural Science*, *118*(2), 188-193.
8. Kara, B., & Atar, B. (2013). Effects of mulch practices on fresh ear yield and yield components of sweet corn. *Turkish Journal of Agriculture and Forestry*, *37*(3), 281-287.
9. Kasirajan, S., & Ngouajio, M. (2012). Polyethylene and biodegradable mulches for agricultural applications: a review. *Agronomy for Sustainable Development*, *32*(2), 501-529.
10. Lalitha, M., Thilagam, K. V., Balakrishnan, N., and Mansour, M.(2010). Effect of plastic mulch on soil properties and crop growth. Agric. Rev., 31 (2) : 145-149.
11. Lament, W. J. (1993). Plastic mulches for the production of vegetable crops. Hort Technology. Jan/Mar.3(1).
12. Ling, D.B., Liu, J. L., Zhu,L., Luo, S.S., Chen, X. P., Li, S. Q., Hill, R. L., and Zhao, Y. (2013). The effects of mulching on maize growth, yield and water use in a semi-arid region. Agricultural Water Management 123: 71-78.
13. Mahajan, G., Sharda, R., Kumar, A., & Singh, K. G. (2007). Effect of plastic mulch on economizing irrigation water and weed control in baby corn sown by different methods. *African Journal of Agricultural Research*, *2*(1), 19-26.
14. Maged. A. El-Nemr. (2006). Effect of mulch types on soil environment conditions and their effect on the growth and yield of cucumber plants. Journal of Applied Sciences Research 2(2): 67-73.
15. McCraw, D., & Motes, J. E. (1991). Use of plastic mulch and row covers in vegetable production. *Cooperative Extension Service. Oklahoma State University. OSU Extension Facts F-6034*.
16. McKee, G. W. (1964). A Coefficient for Computing Leaf Area in Hybrid Corn 1. *Agronomy Journal*, *56*(2), 240-241
17. Runkle, E. 2015. Light wavebands and their effects on plants. /gpn/ March 2015.WWW.GPNMAG.COM.
18. Tesfaye, T., Tigabu, E., Germadu, Y., & Lemma, H. (2016). Effect of colored polyethylene mulch on soil temperature, growth, fruit quality and yield of tomato (Lycopersicon esculentum Mill.). *World J. Agric. Sci*, *12*, 161-166.
19. Zhang, D. Q., Liao, Y. C., & Jia, Z. K. (2005). Research advances and prospects of film mulching in arid and semi-arid areas. *Agricultural Research in the Arid Areas*, *1*, 041.
20. Zhou, L. M., Li, F. M., Jin, S. L., & Song, Y. (2009). How two ridges and the furrow mulched with plastic film affect soil water, soil temperature and yield of maize on the semiarid Loess Plateau of China. *Field Crops Research*, *113*(1), 41-47.